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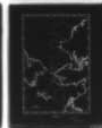
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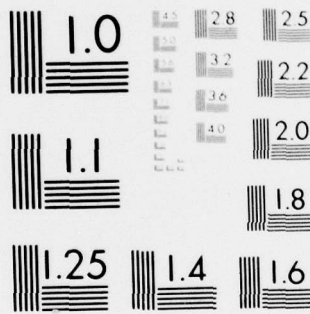
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Technical Report No. 70

RECOVERY OF DRIFT BOTTLES RELEASED IN THE
SOUTHEASTERN CHUKCHI SEA AND NORTHERN BERING SEA

by

Richard H. Fleming and Diane Heggarty

Brown Bear Cruise 268
26 July to 28 August 1960

U.S. Atomic Energy Commission
Contract AT-45-1-540
and
Office of Naval Research
Contract Nonr-477(10)
Project NR 083 012

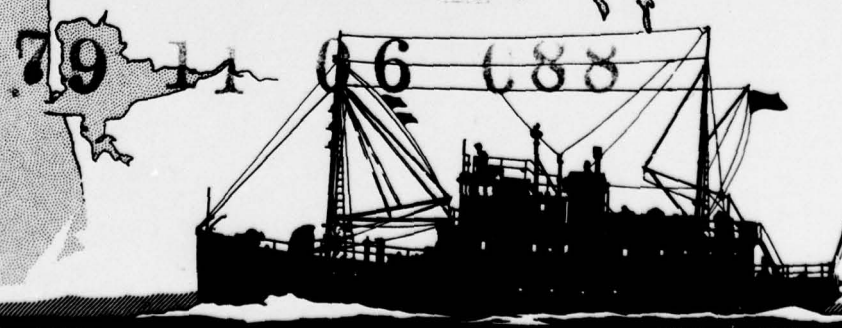
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Richard H. Fleming
RICHARD H. FLEMING
Chairman

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ABSTRACT

INTRODUCTION

During July and August of 1960, the Department of Oceanography, University of Washington, conducted an oceanographic survey of the northern Bering and southeastern Chukchi Seas. Brown Bear Cruise 268 was a part of Phase Three of Project Chariot and was jointly supported by the Office of Naval Research and the U. S. Atomic Energy Commission.

During the summer of 1959, the department made a survey of a more limited area in the same region. The studies in 1959 in the southeastern Chukchi Sea showed fairly strong northerly currents and pronounced east-west gradients in the distributions of properties. Because of the importance of the currents in controlling the physical, chemical and biological conditions, the 1960 survey was designed to verify the 1959 data and to obtain more complete observations on the currents (Fleming and Staff, 1960-61).

Part of the program to study the surface currents in the summer of 1960 was the release of drift bottles. A total of 1653 bottles was released at 35 locations in the northern Bering Sea and the southeastern Chukchi Sea (Figure 1). Approximately 50 bottles were released at each of 5 stations in the Bering Sea, at 3 stations in Bering Strait and at 27 stations in the southeastern Chukchi Sea. In October and November of 1960, the U. S. Coast Guard icebreaker Northwind (WAGB-282) released 200 bottles of the same type (University of Washington, Department of Oceanography, Unpublished). Bottles were released at one station in the Beaufort Sea, 5 stations in the Chukchi Sea and 2 stations in the Bering Sea (Figure 2).

DESCRIPTION OF BOTTLES

The bottles used were 6-ounce, long-necked bottles, ballasted with sand so that an inch of the neck protruded above the water (Figure 3). Cards were enclosed containing instructions to the finder, in English, Japanese and Russian, to break the bottle and to report the recovery to the Department of Oceanography (Figure 4). The finder was asked to state when and where he found the bottle and a \$1.00 reward was given for each card returned. The cards were numbered so that the release point of the individual bottle could be identified. The bakelite screw caps were sealed with a microcrystalline wax. No particular effort was made to provide for a long life of the drift bottles because it was felt that returns after the first summer would be difficult to interpret. However, during the summer and fall of 1961, a total of 33 recoveries was reported, indicating that the bottles were capable of surviving at least one winter.

5-METER CURRENTS

Observations made in 1959 had indicated that the currents at a depth of 5 meters were representative of the near-surface flow. These observations also showed that, in much of the area, tidal currents and

other periodic currents that might be associated with internal waves or inertial movements were small compared to the "permanent" flow. During 1960, 5-meter current measurements were made for brief periods at the locations shown in Figure 5. All observations were made with a recording Magnesyn current meter, a modification of the von Arx meter (von Arx, 1950). The threshold velocity of this instrument is approximately 0.2 knot.

The current measurements from the northern Bering Sea are probably inadequate to properly define the surface circulation in this area. However, it is clear that the dominant feature both here and in the Chukchi Sea is the general northward movement of the water. This movement is modified by the coastal outline and by the bottom topography. Winds must also affect the circulation pattern but no clear understanding of the effect of the wind could be drawn from the observations made in 1959 and 1960.

In general it can be stated that the currents tend to follow the depth contours rather than the coastal outline. For example, the northward flow through Bering Strait continues a considerable distance beyond Cape Prince of Wales before turning towards the east and the development of the shoal in this area is undoubtedly associated with this flow pattern.

Similar conditions apparently prevail at Point Hope. In both locations clockwise eddies appear to be present to the north and east of these points. No current observations are available from Norton Sound but the distribution of temperature and salinity in the adjacent areas indicates that the flow during the summer months is dominated by a counter-clockwise movement.

The general features of the surface circulation based on the 5-meter current measurements have been used in constructing the probable trajectories of the drift bottles.

1960 RETURNS

By December 1, 1960, the recovery of a total of 129 bottles had been reported to the Department of Oceanography (Figure 6). By this time of the year, ice covered most of the region and no returns were reported until the following summer.

Recoveries from station 9 near the mouth of the Yukon River were reported from St. Michael and Shaktolik in Norton Sound. Bottles from the Bering Sea stations 12, 19, and 23 were found with greatest frequency at Shishmaref and Cape Espenberg. Station 19 had the largest percentage of recoveries from stations south of the Strait, namely 39 percent. One bottle from this group was recovered at Ekpeek, just north of Cape Prince of Wales. Only one bottle from a Bering Strait station was recovered in 1960, a single bottle from station 30 being found near Shishmaref.

North of the Strait, station 31 had a 56 percent recovery, the greatest number of bottles being found at Shishmaref. The only offshore station that had any returns was station 37 from which one bottle was recovered near Ogotoruk Creek. Bottles from stations 42 and 52, both inshore locations, were recovered in fairly large numbers on the coast at Cape Thompson and Point Hope. Bottles from station 43 drifted onto the beach near Kivalina and 96 percent of the bottles were recovered.

Average speeds of drift have been computed for the recoveries made in 1960 (Appendix I). Although such estimates are uncertain because of the unknown trajectories followed, and tend to be minimal because of the unknown periods of time the bottles were on the beach before being found, these drift speeds are in the same general range as those obtained from the current measurements. Both brief drifts, on the order of a few days--for example, recoveries from station 42 and 43--as well as longer drifts, on the order of 50 or more days--for example, recoveries from stations 9, 12, 19 and 23--indicate average speeds of between 0.1 and 0.5 knots.

In a few cases where the duration of the drift was very short--for example the recoveries at Point Hope of bottles from station 42--it is probable that the dates of recovery were incorrectly reported by the finders. The last column in Appendix I gives the average speeds of drift along the trajectories shown in Figure 6, based on the current speeds observed at a depth of 5 meters (Figure 5).

1961 RETURNS

Thirty three bottles were returned to the Department of Oceanography between the ice break-up in the summer of 1961 and January 1, 1962 (Figures 7 and 8 and Appendix II). Releases from several additional stations were represented among these recoveries. The most distant drifts among these recoveries were for bottles found in Russian waters from five stations in Bering Strait and the Chukchi Sea (Figure 8). One return from station 28, the western station in Bering Strait, was found near the mouth of the Rau-Chua River on the East Siberian Sea. Two bottles from station 41 and one from station 50 were also recovered from near the Rau-Chua River. Another Russian recovery was a station 37 bottle which was found near Cape Schmidt in Siberia. One bottle from station 98 was found on the south coast of Wrangel Island. The bottles from stations 28 and 37 probably followed the same general trajectory as the bottles from 41, 50 and 98. One went into Wrangel Island, one was caught in the current running south along the Siberian Coast and the other four continued to the mouth of the Rau-Chua River on the coast of the East Siberian Sea.

The recovery dates of these bottles--approximately one year after their release--reflect the distances they drifted. The Wrangel Island recovery from station 98 was made near the end of June, as was the station 37 recovery near Cape Schmidt. The bottles from stations 28 and 41 were recovered between August 20 and 23, 1961, at the mouth of the Rau-Chua River, and the station 50 bottle was recovered at the same place on September 8, 1961.

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The comments concerning the Russian recoveries imply that the bottles did not reach the recovery localities until the summer of 1961. Minimum trajectories are about 360 nautical miles for the bottle found on Wrangel Island and in excess of 600 miles for the bottles found near the mouth of the Rau-Chua River. Ice cover in the area is complete by late October so that the bottles would be frozen in the pack ice approximately two months after release. To have completed their drifts in a two month period would have required average speeds of between 0.25 and 0.5 knots. It is possible for the bottles to have completed their drift by October 1960, but this is considered as unlikely because the trajectories were undoubtedly longer than the distances mentioned. It is therefore believed that the bottles were frozen into the ice and drifted with the pack for a major part of the time they were at sea.

The recoveries in 1961 from the coast of Alaska confirmed the returns reported the previous year. Returns from station 9 at Shaktolik in the eastern part of Norton Sound and at Cape Wooley and Cape Douglas, located to the north of Norton Sound, further confirmed a counterclockwise circulation in the Sound. Other recoveries of bottles released in the Bering Sea and in the southern Chukchi Sea were concentrated in the Shishmaref - Cape Espenberg region. Further to the north, bottles from inshore stations 42 and 52 were again recovered near Point Hope.

By January 1, 1962, only one bottle had been recovered from the Northwind releases. A bottle from station 2.70, to the east of St. Lawrence Island, was recovered in the vicinity of Cape Nome (Figure 2).

DISCUSSION

During the summer of 1960 a total of 1653 drift bottles was released at 35 locations in the northern Bering and southeastern Chukchi Seas. During October and November a total of 200 additional bottles was released at eight stations extending from Bering Sea to the Beaufort Sea. Prior to December 1, 1960, a total of 129 recoveries had been reported from the summer releases representing a 7.8 percent return. During the following year, 33 additional recoveries were reported to increase the total to 9.8 percent of the bottles released during the summer cruise.

This was a much higher recovery rate than had been anticipated and merits some explanation. First, it must be recognized that most of the Alaskan coastline in the Chukchi Sea is made up of beaches of sand and fine gravel, therefore bottles reaching the beach are not likely to be smashed. Furthermore, the inhabitants of the villages in the area spend considerable time on the beaches near their homes collecting drift wood. During the summer months the beaches are the principal routes of land travel and other activities and it is probable that the large number of recoveries must be attributed in part to the effective combing of the beaches. The populations of the principal coastal villages are shown in Figure 1. These are based on the 1960 census.

One striking aspect of the survey was the relatively large number of recoveries from the beaches near Shishmaref, Cape Espenberg, Kivalina

and Point Hope. Of the 162 recoveries reported in 1960-1961, 79--or 49 percent--were from the Shishmaref - Cape Espenberg area, 46--or 28 percent--from near Kivalina, and 28--or 17 percent--from near Point Hope. As these four localities are at or near the sites of villages, this local concentration of reported recoveries may be partly due to the intensity with which the nearby beaches are scanned.

One of the puzzling anomalies in the reported recoveries is the lack of any returns from Kotzebue Sound. No bottles were released in that area but the relatively large numbers found near Cape Espenberg and the general character of the circulation suggests that a number of bottles might have been carried into the Sound. In addition to Kotzebue there are three villages in the southern part of the Sound from which recoveries might have been anticipated.

A number of bottles released in the Bering Sea were recovered in the Shishmaref - Cape Espenberg area. Furthermore, over 50 percent of the bottles released at station 31 was found in the same area during the summer of 1960. It is therefore surprising that only one bottle was recovered from the releases at station 30 and none from stations 32, 33 and 40.

With the exception of bottles from stations 31 (and a single bottle from station 37 found at Ogotoruk Creek) all of the recoveries on the Alaskan beaches from releases made in the Chukchi Sea were from the stations close to the coast. As already mentioned, this does not imply that bottles from all nearshore stations were recovered. The lack of recoveries on the Alaskan coast from the "offshore" stations indicates that the greatest number of bottles were carried northward and into the Arctic basin. The recovery during 1961 of six bottles on Wrangel Island and the north coast of Siberia--all from "offshore" stations (28, 37, 41, 50 and 98)--confirms this interpretation. The only anomaly in this case is that one bottle from station 37 was recovered at Ogotoruk Creek in 1960.

Historically, there is little direct evidence of the flow from Bering Strait to the Siberian coast. Many whaling ships were trapped in the ice between 1850 and 1900 but observations of their drift are generally unavailable. In 1881 Captain C. L. Hooper of the Revenue Marine Cutter, Thomas Corwin, reported that part of a vessel that burned south of Bering Strait was found near Herald Island. Hooper also reported that the whaling bark, Vigilant, trapped in the ice near Herald Island in early October 1879, was sighted from the eastern coast of Siberia the following October (Hooper, 1884).

The direction of flow in the strait between Wrangel Island and the mainland of Siberia has also been in doubt. Captain Hooper, while cruising August 4, 1881, in Proliv Longa (De Long Strait), reported a current set of 12 miles per day in a west-northwesterly direction. The wind at the time was light and variable. Yu. A. Gorbunov in 1957 published a paper on the water exchange through Proliv Longa (Gorbunov, 1957). Current measurements were made in 1952, 1953 and 1956 with both current meters and radio buoys. Gorbunov came to the conclusion that the current direction and velocity in the Strait is dependent on the wind regime.

With continuing southeasterly and easterly winds, the water transport is from the Chukchi to the East Siberian Sea. Under steady winds from the west and northwest, water transport is from the East Siberian to the Chukchi Sea. With unsteady winds, the exchange has a more complicated pattern.

Winds are apparently the most important factor in the general drift in the northern Chukchi Sea. Sverdrup believed that at the boundary of the Chukchi Sea the winds are directed to the west and that the average drift takes place in that direction. This westward drift is shown by the drift of the Karluk in 1913 (Sverdrup, 1956). The Karluk was frozen into the ice north of Lion Reef in the Beaufort Sea September 30, 1913, and sank near Herald Island on January 11, 1914, at 72°11' N and 174°36' W (Bartlett, 1916; U. S. Hydrographic Office, 1958).

It is always difficult to explain precisely how drift bottles do get washed ashore. Onshore transportation must be furnished either by wave action or by action of the wind on the exposed portion of the bottles which would cause them to sail relative to the water. Winds during the summer (June-August) appear to be dominated by air movements either from the northerly or southerly quadrants with the northerly winds being stronger at Point Hope and the southerly winds stronger in Bering Strait (U. S. Coast and Geodetic Survey, 1954; U. S. Weather Bureau, 1944). Westerly winds dominate at Kotzebue. At Shishmaref, where only directions have been reported, the winds are almost equally divided between northerly and southerly (U. S. Weather Bureau, 1944). During the autumn quarter (September-November) the northerly winds increase in frequency and intensity, and consequently the winds of late summer and early autumn may be the principal factor in the relatively large number of recoveries in the Shishmaref - Cape Espenberg area. Although observations from Ogotoruk Creek indicate a predominance of offshore winds during the late summer and autumn, there are periods of several days duration with onshore winds (U. S. Weather Bureau, unpublished). It must be admitted, however, that the climatic wind conditions in the southeastern Chukchi Sea do not offer any obvious solution as to why so many of the bottles in the inshore water did reach the beach.

In view of the relatively high percentage of recoveries from bottles released in the Bering Sea it is unfortunate that more releases were not made in these waters.

SUMMARY

1. During August 1960, a total of 1653 drift bottles was released in the northern Bering and southeastern Chukchi Seas. During October and November 1960, 200 additional releases were made.
2. Prior to 1 December 1960 a total of 129 recoveries was reported from the releases made in August. During the summer and fall of 1961, 34 additional recoveries were reported, 33 from the summer stations and one from the fall releases.

3. The recoveries confirm the general northward transport of water in the area. Virtually all recoveries along the Alaskan coast of bottles released in the Chukchi Sea were from stations located near the coast.
4. During 1961 six recoveries were reported from the USSR, one from Wrangel Island and the others from the Siberian coast.

ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance of Dr. Robert G. Paquette and Mr. Gerald Schimke who selected the type of bottle to be used, designed the enclosed cards and supervised their preparation for release. Our thanks are also extended to the many individuals who reported finding the bottles. Without their cooperation there would have been no report to make. Financial assistance in this project was provided by the Office of Naval Research and the Atomic Energy Commission.

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APPENDIX I

Recoveries Reported Prior to December 1, 1960

Release Point Station No.	Recovery Point	No. of Bottles	Percentage Return	Fastest Time of Travel (days)	Average Time of Travel (days)	Estimated Speed (knots)	Estimated Speed from 5 m currents (knots)
9	St. Michael	1			49	.10	.50
9	Shaktolik	1	1.9		69	.10	.50
12	Shishmaref	2			45	.20	.40
12	Cape Espenberg	4	12.8		45	.20	.40
19	Shishmaref			13		.50	.30
19	Shishmaref	12			34	.20	.30
19	Ekpeek	1			29	.10	.20
19	Cape Espenberg	9	39.3		45	.20	.30
23	Shishmaref	5			45	.20	.20
23	Cape Espenberg	1	12.0		52	.20	.20
30	Shishmaref	1	2.1		10	.30	.30
31	Shishmaref			11		.10	.30
31	Shishmaref	23			21	.10	.30
31	Cape Espenberg	4	56.4		15	.30	.30
37	Ogotoruk Creek	1	2.1		22	.40	.30
42	Point Hope			2		2.0	.50
42	Point Hope	3			4	.90	.50
42	Ogotoruk Creek	2	10.4		6	.50	.40
43	Kivalina	46	96.0		5	.20	.20
52	Point Hope			0			.50
52	Point Hope	10			16	.10	.50
52	Cape Thompson	3	27.0		15	.03	.60

APPENDIX II

Recoveries Reported Between December 1, 1960 and January 1, 1962

Release Point Station No.	Recovery Point	No. of Bottles	Percentage Return 1960 and 1961
9	Shaktolik	1	
9	Cape Wooley	1	
9	Cape Douglas	1	
12	Cape Espenberg	4	17.4
12	Wales	1	
19	Cape Espenberg	5	23.5
19	Shishmaref	2	
23	Cape Espenberg	2	52.0
23	Shishmaref	1	
28	Siberia - Mouth of Rau-Chua River	1	18.8
	Cape Espenberg	3	2.1
31	Shishmaref	1	
31	Cape Schmidt	1	64.6
37	Siberia - Mouth of Rau-Chua River	2	4.2
41	Point Hope	3	4.2
42	Siberia - Mouth of Rau-Chua River	1	16.7
50	Point Hope	1	2.1
52	S. Coast of Wrangel Island	1	29.2
98	Cape Nome	1	2.8
	Cape Espenberg	1	
	Cape Espenberg	1	
Northwind 2.70			
Station unknown			

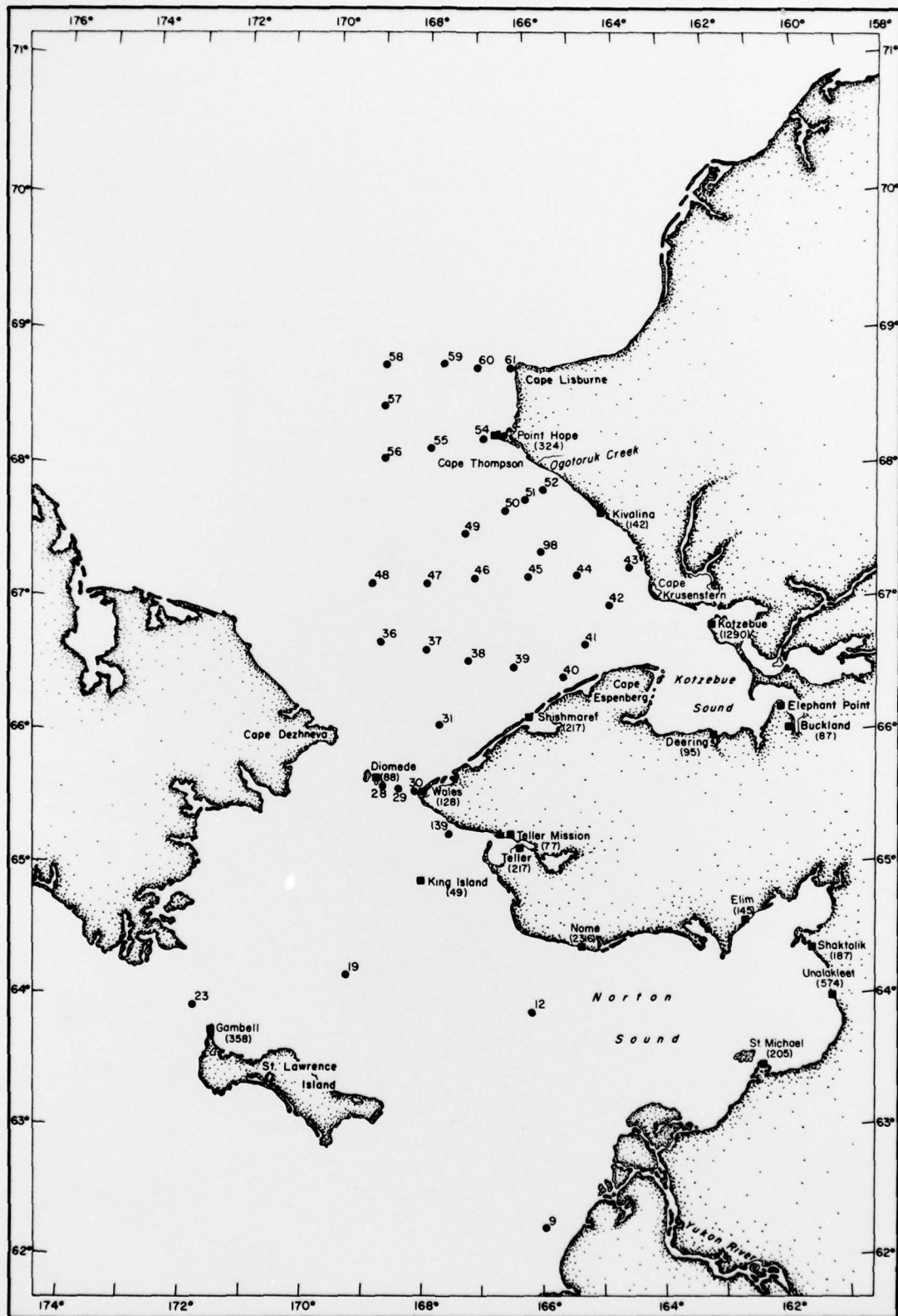


Figure 1

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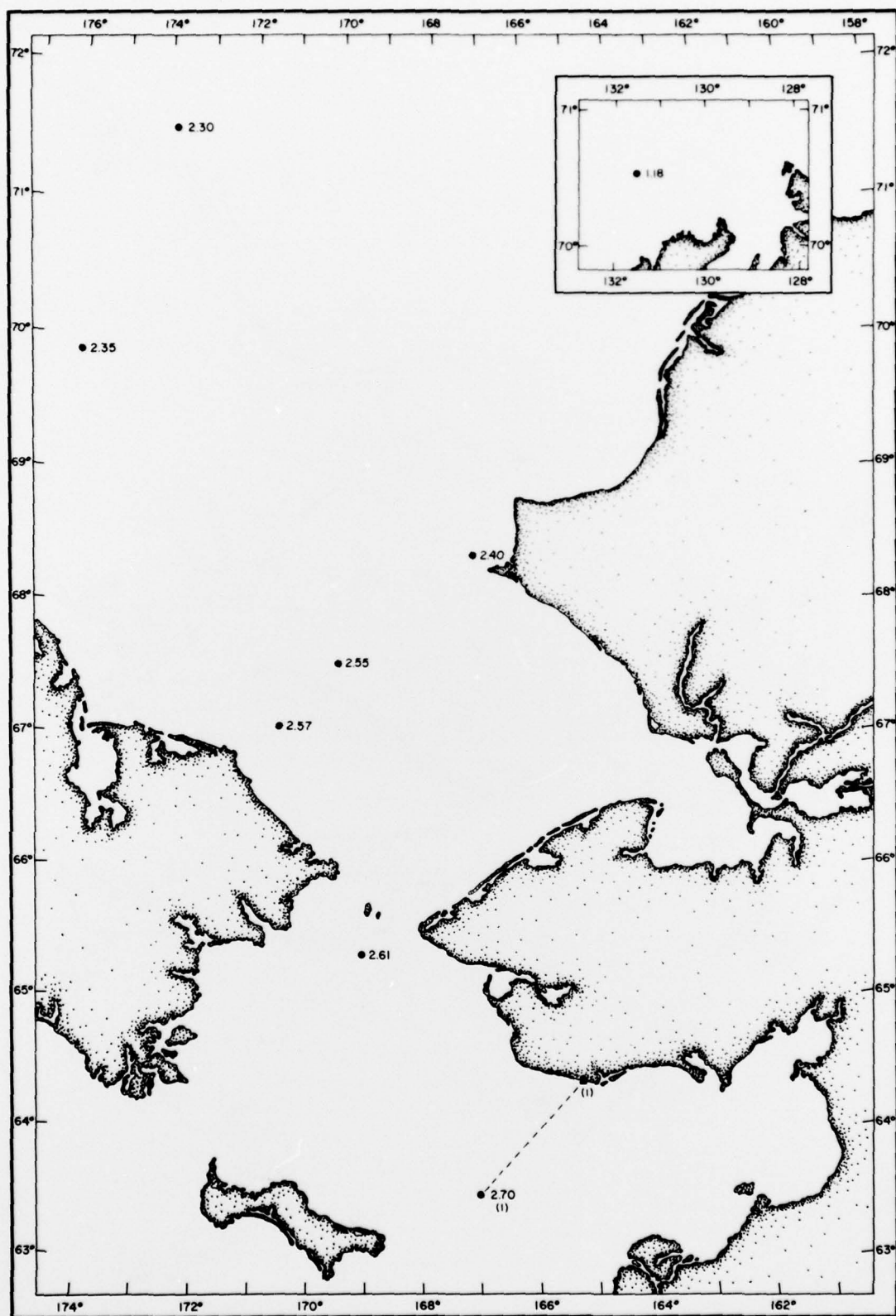


Figure 2

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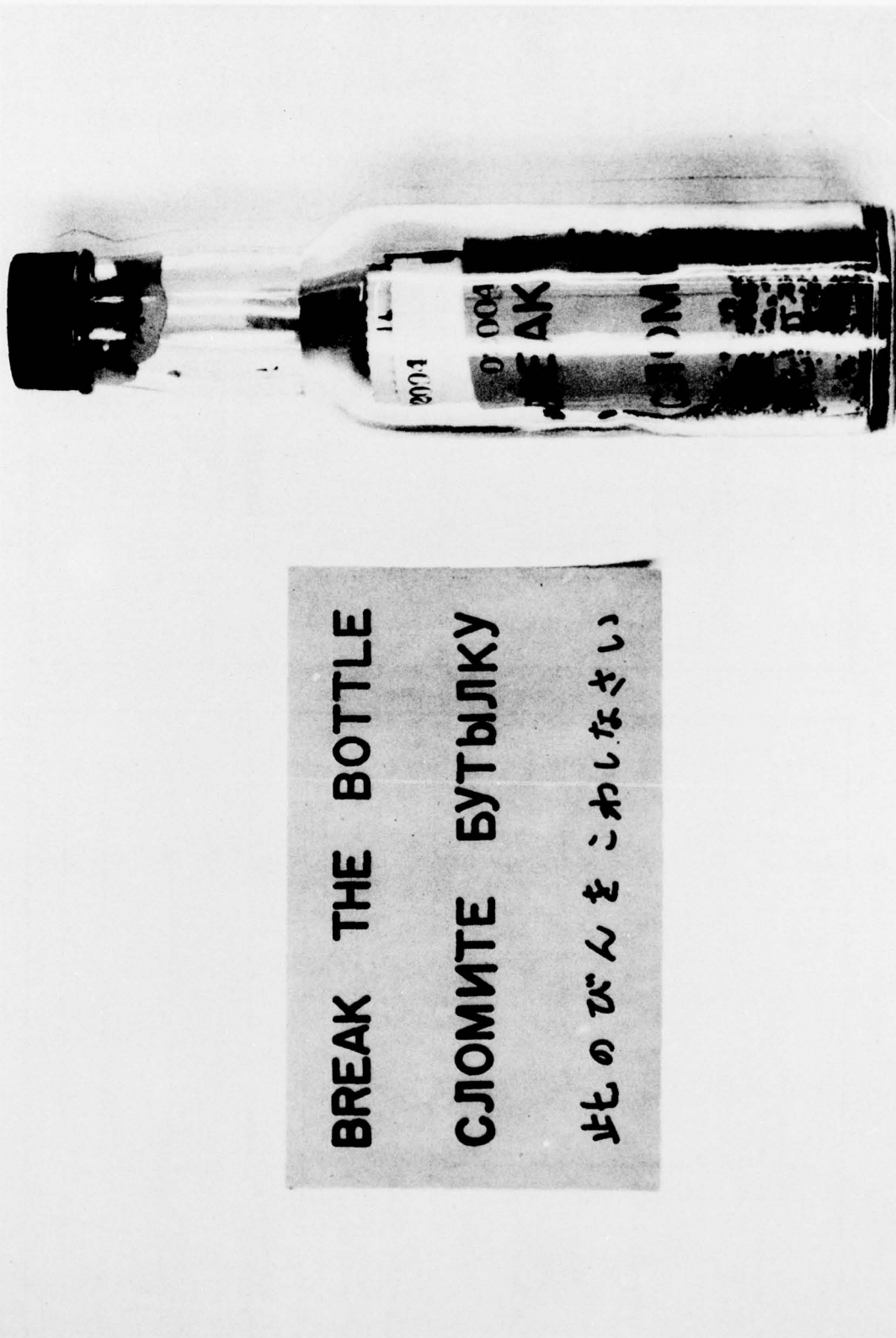


Figure 3

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<p>Keep this half as a receipt. Please PRINT in block letters</p>	<p>Вы можете держать первую полкарту. Пишите печатными буквами</p>	<p>以上の半分を受取証として保持して下さい。 英字はゴシック体の大文字で書いて下さい。 此ノ葉書半分</p>
<p>Tear Here</p>	<p>Отрываете тут</p>	
<p>海流図の招待状 Где нашли бутылку? Where did you find the bottle?</p>		
<p>招待状 Когда нашли бутылку? When did you find the bottle?</p>		
<p>招待状 Ваша фамилия Your name is</p>		
<p>招待状 Ваш адрес Your address is</p>		

<p>DEPARTMENT OF OCEANOGRAPHY UNIVERSITY OF WASHINGTON WILL PAY</p>	<p>УНИВЕРСИТЕТ ВАШИНГТОН ОТДЕЛ ОКЕАНОГРАФИЧЕСКИЙ ЗАПЛАТИТ</p>	<p>ワシントン大学 海洋学部は</p>
<p>ONE DOLLAR REWARD FOR THE RETURN OF THE OTHER HALF OF THIS CARD</p>	<p>НАГРАДА ОДИН ДОЛЛАР ДЛЯ ВОЗВРАЩЕНИЯ ДРУГУЮ ЧАСТЬ ЭТОЙ КАРТЫ</p>	<p>此のカードの 他の半分を お返し下さい 方には 毫弁を呈します</p>

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Figure 4

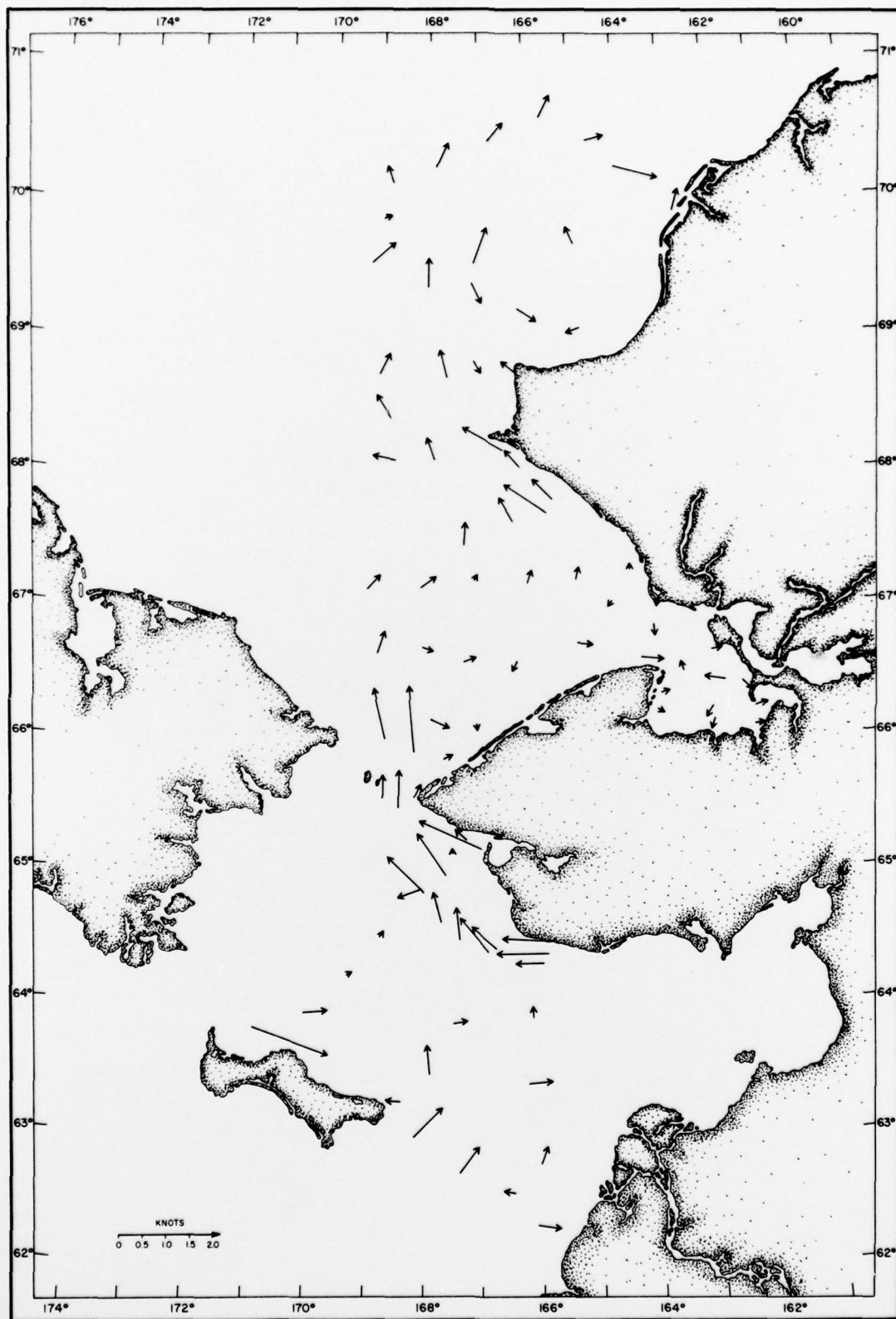


Figure 5

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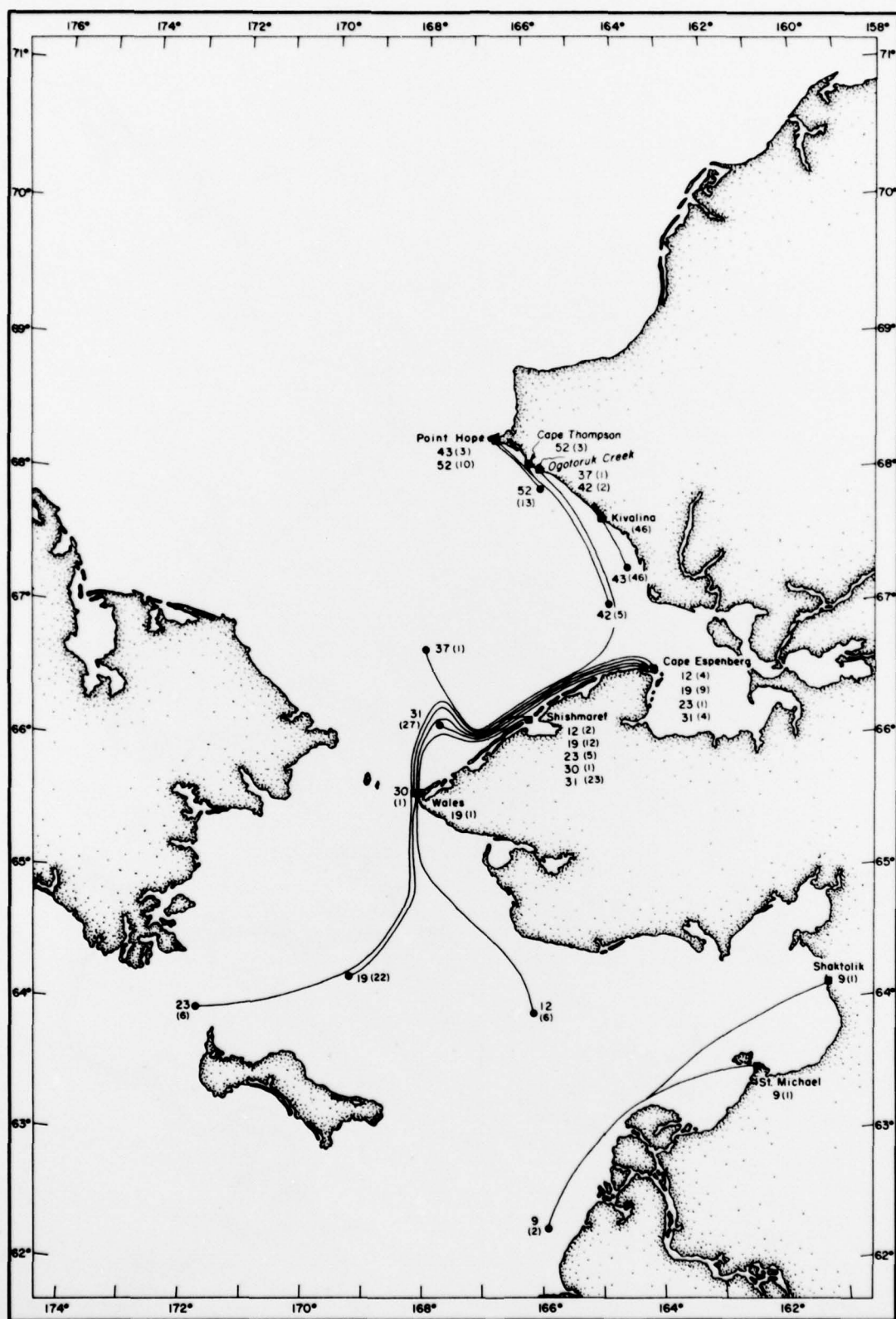


Figure 6

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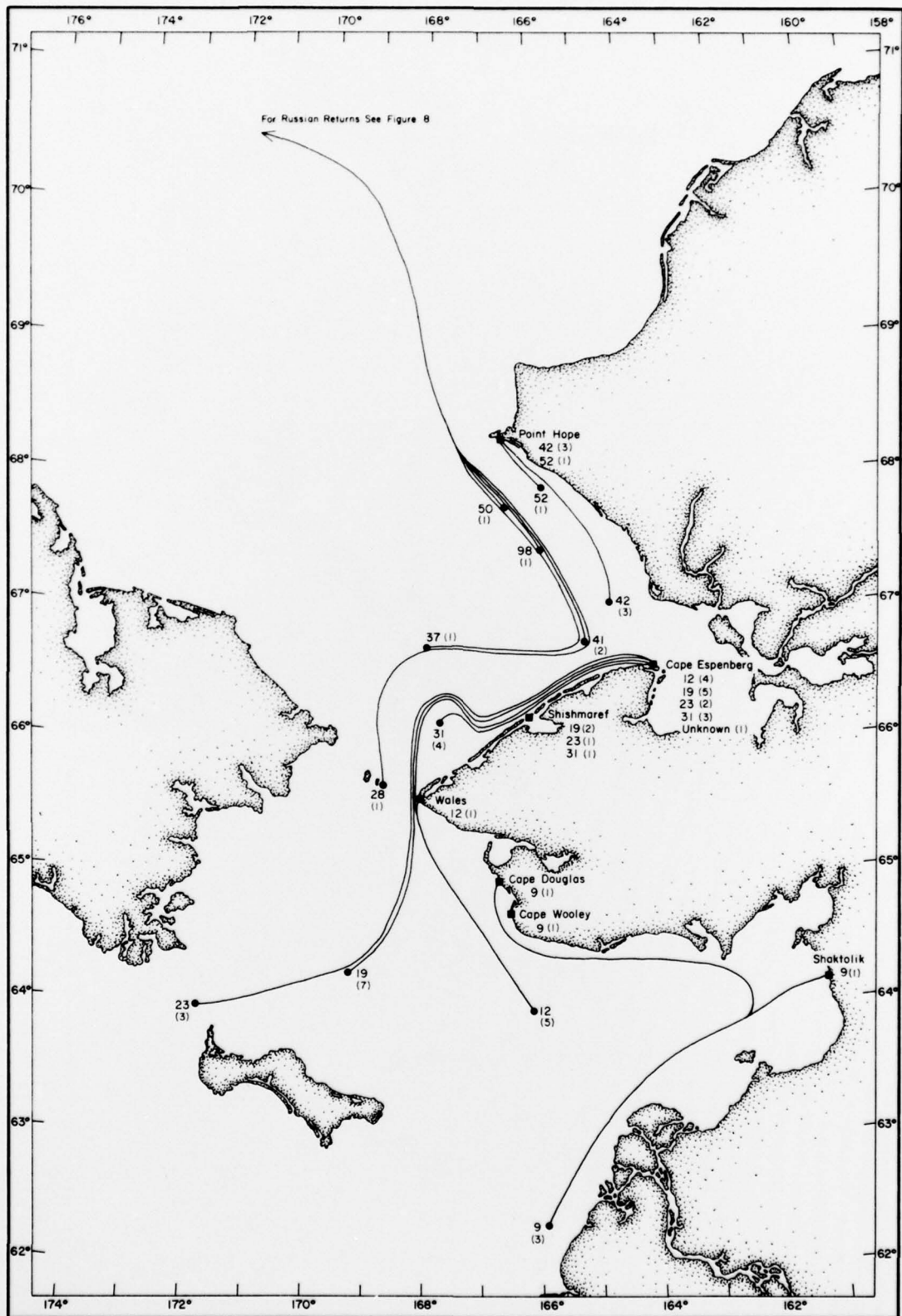


Figure 7

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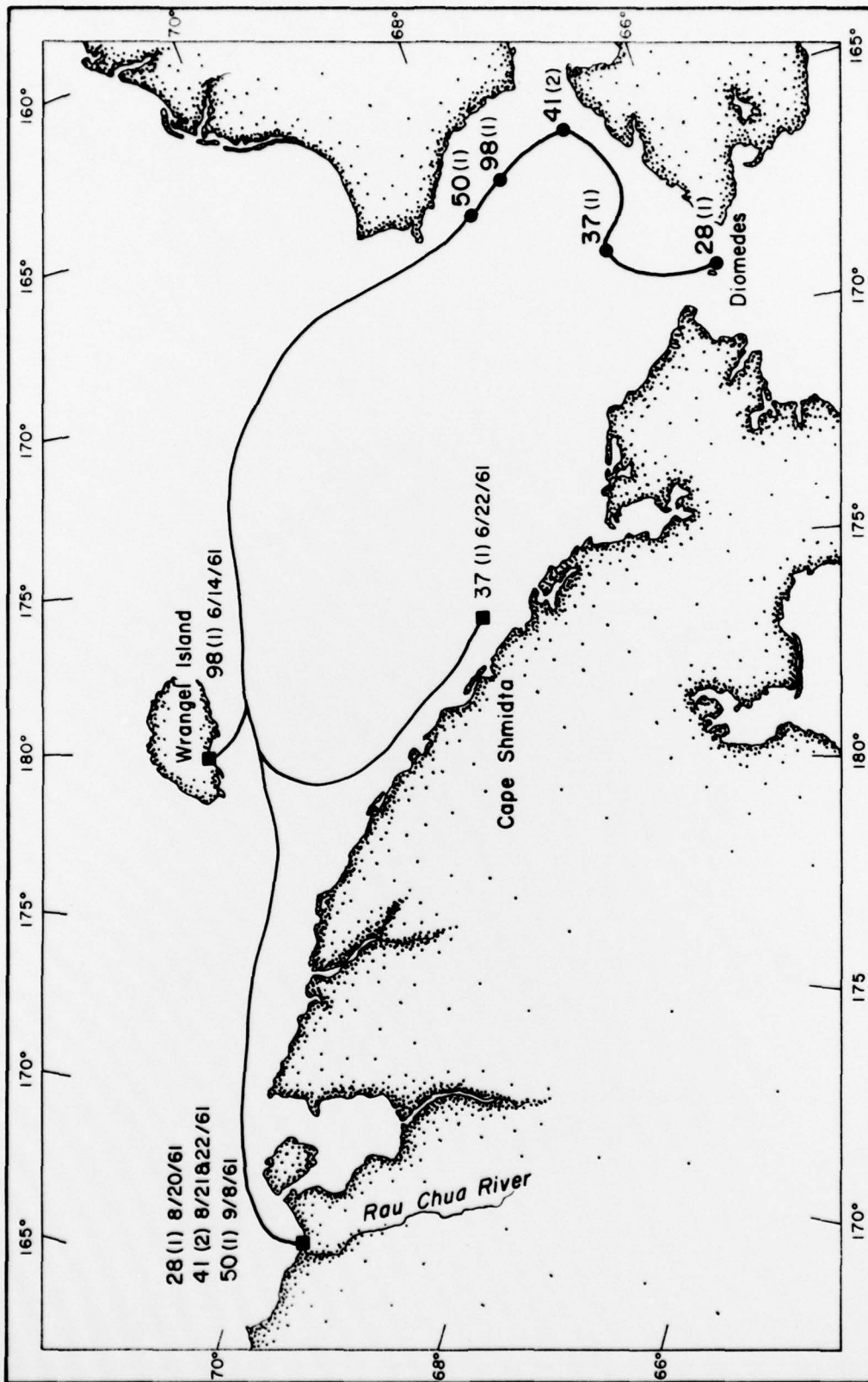


Figure 8

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